CHAPTER II

THE PHYSICAL BACKGROUND OF MAGUGU

<u>Site.</u>--The site of Magugu, a spectacular one, is in the Rift Valley. Southward from the village it appears that Magugu is in one huge crater. Ten miles to the south, the Dareda Ridge marks the extreme southern extent of the interior drainage basin into Lake Manyara (Fig. 45). On the east are Sangaiwe and Kirogwa ridges, remnants of the eastern Rift Wall (Fig. 46). To the west the tremendous western Rift Wall forms sheer cliffs as high as three thousand feet above the valley floor (Figs. 47 and 48). On the rim of the Rift, peaks, such as Hasanna, tower nearly five thousand feet above Magugu and the valley floor.

If one looks northward, the illusion of the crater is destroyed, for the eastern ridges disappear north of Magugu, and to the east the Masai Steppe stretches for hundreds of miles (Fig. 49). Directly north the land slopes gently to Lake Manyara which is partially blocked from view by the rough edges of the low Besi Hill. Beyond the lake stretches more of the slightly sloping basin that drains into Manyara from the north. However, the western Rift Wall continues unbroken as far as the eye can see (Fig. 50). Its immensity dominates all. The great heights of the Wall often shrouded in mist or cloud, the interplay of sun and shadow on the varied colored rocks and the somber depth of the valley at

Fig. 45.--Looking south from the village. In the far background is Mt. Ufiomi; to the right begins the Dareda Ridge.

Fig. 46.--Facing east in Magugu. The Sangaiwe Ridge lies in the background. The ridge declines in elevation on the left of the picture, i.e. to the north. A few miles north the ridge disappears entirely.

Fig. 47.--The western Rift Wall from across the saline flats of Mbugwe.

Fig. 48.--A close-up of the Rift Wall showing the sheer cliffs towering over Magugu.

Fig. 49.--Looking north from Dareda. To the left the Rift Valley stretches uninterruptedly to Lake Manyara. In the background Sangaiwe Ridge disappears in the distance to reveal the Masai Steppe.

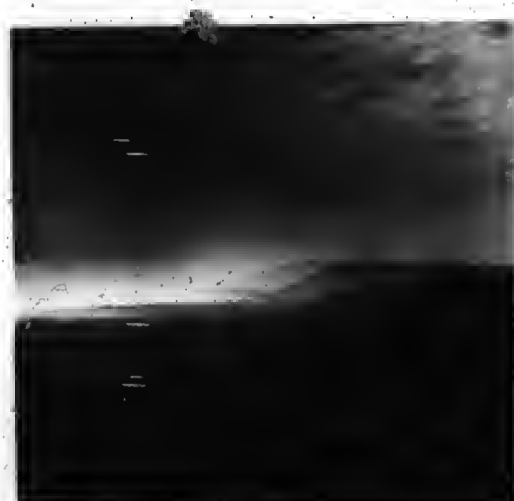

Fig. 50.--Looking south from Mto Wa Mbu. The western Rift Wall is on the right, and in the rear is Lake Manyara. Beyond the lake lies Magugu.

dusk, and the glimmering expanse of Masai Steppe at high noon--these are pictures that vie with the rushing and plunging waters of Victoria Falls, with Ngorongoro Crater, or the majestic slopes of Kilimanjaro. From Magugu, Kilimanjaro, over a hundred miles away, creates, on a clear day, the impression that a huge cloud of snow is overlooking the countryside.

Topography.--The actual site of Magugu, nearly histrionic in scope, is in direct contrast to the monotony of the topography of the resettlement area itself. The nearly flat surface is interrupted only in a few places by a small ridge of sand or by a shallow mbuga depression (Figs. 51, 52 and 53). Sino Hill, nearly a perfect cone representing an erosional remnant of the pre-Rift Valley peneplain, stands nearly seven hundred feet higher than the land around it like a sentinel overlooking the bottom of the valley (Fig. 54). As the area is part of the old lacustrine plain of Lake Manyara, Sino at one time was undoubtedly a small island in the old lake.

Because of the slight slope of the land towards Manyara much of the area, due to minor local configurations, does not initially drain north towards the lake. It either drains westward to the present Tindiga Swamp or northeastward to Lake Burungi which formerly was joined to Manyara but is now a separate saline lake with no outlet even in the rainy season (as, of course, is Manyara). Hence, though the Tindiga

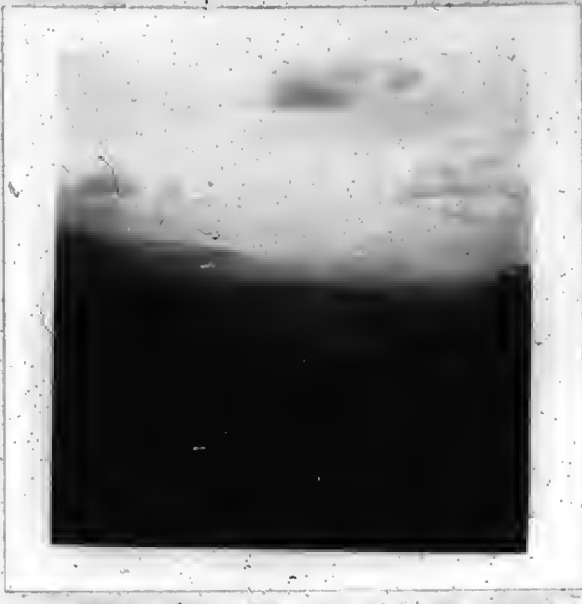

Fig. 51.--The flat Rift Valley from the top of Sino Hill. In the background, to the southeast, is Sangaiwe Ridge.

Fig. 52.--The Rift Valley northwest of Sino Hill. To the west rises the Rift Wall.

Fig. 53.--The trading settlement. The approach to the trading settlement from the north emphasizes the flatness of the topography. In the background is a baobab tree, a remnant of pre-clearing vegetation. The highway is the Great North Road.

Fig. 54.--Sino Hill rises like a sentinel overlooking the floor of the Rift Valley.

Swamp drainage eventually enters Manyara, water in the area to the northeast of the present Magugu trading center does not. Instead it evaporates in the Burungi mbuga or enters Lake Burungi itself.

Because of the flatness of the area much of the water in the streams and underground seepages is absorbed by the soil or evaporates before reaching the lake proper. Even the stream coming from the great Tindiga Swamp becomes so low during the dry season that automobiles can cross it (Fig. 55). From the southern portion of Magugu to the shores of Lake Manyara there is a gradual slope of only two hundred feet in a distance of over twenty miles (Fig. 56).

In places Magugu is so flat that engineers in constructing the irrigation ditch had to utilize every local configuration to get enough fall for the water. One of the problems of Magugu is still one of containing the water within the ditch where it has a tendency to spread over the countryside and form minor swamps. Between January and June, 1954, it was never possible to walk the complete length of the ditch from Magugu to its northern terminus, because ill care had permitted the water to flood a large area just north of the trading settlement. Nevertheless, since the gentleness and uniformity of the slope has precluded the presence of any topographic barriers to cultivation, once the problem of drainage is solved, there should be no reason, other than soil fertility, why all of Magugu should not be utilized for agricultural purposes.

Fig. 55.--The stream flowing out of the Tindiga Swamp. During the dry season vehicles can drive through this stream, but during the wet season it is over a mile wide. In the background is Sino Hill.

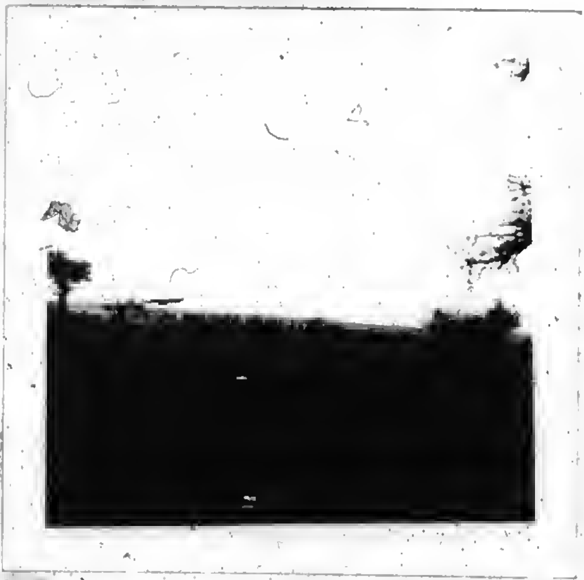

Fig. 56.--The flat lacustrine plain of Lake Manyara. In the distance along the shores of the lake is a large herd of zebra.

Location.--Though Magugu's site is magnificent and its topography excellent, its location is relatively bad. It is only twenty miles from Mbulu, capital of the administrative district in which Magugu is located, but because of lack of roads up the face of the Rift Wall, Magugu is nearly one hundred miles from Mbulu by road. Also, the roads available for this journey are the kind that break a car's axle at speeds over thirty, choke the driver with dust when it is dry, and mire him down when it is wet. As a result Government officials have a tendency to ignore the Magugu community more than they do the more easily accessible parts of the district.

Magugu is also remote from the provincial capital of Arusha(Fig. 57). It is ninety-five miles southwest of Arusha on the main north-south highway of Tanganyika, the Great North Road (Fig. 58). In most other areas of the world it would be presumptious to call this highway either "Great" or at certain times of the year even a "Road", for like the Magugu-Mbulu roads, the Great North Road, without a hard surface, has the usual dust-mud conditions, depending on the season (see Fig. 53). Indicative of the quality of this highway is the fact that for large portions south of Magugu bridges are lacking across streams, and the main maintenance instrument in the Magugu area seems to be trees dragged behind tractors or trucks in an attempt to level off the corrugations. This method, plus groups of Africans with hand hoes and rakes,

EAST AFRICA
KENYA
UGANDA
SOMALILAND
L. Albert
Kampala
Entebbe
Kisumu
MT. KENYA
L. Edward
LAKE VICTORIA
Nairobi
L. Kivu
RUANDA
Mwanza
L. Natron
Lake
SERENGETI
Northern
MT. KILIMANJARO
MT. MERU
URUNDI
Arusha
Moshi
L. Eyasi
L. Manyara
Mbulu
Magugu
Mombasa
MASAI STEPPE
Kigomo
Ujiji
Tabora
Tanga
LAKE TANGANYIKA
TANGANYIKA
Tanga
Albertville
Dodoma
ZANZIBAR
Western
Central
Dar es Salaam
INDIAN OCEAN
Iringa
L. Rukwa
Southern Highlands
Eastern
Mbeya
Lindi
Southern
N. RHODESIA
NYASALAND
LAKE NYASA
Lake Bangweulu
MOZAMBIQUE
NATIONAL BOUNDARIES
PROVINCIAL BOUNDARIES
Scale in Miles

Fig. 58.--A sign at Arusha explaining the town's strategic location. Arusha is the nearest city of any size to Magugu, ninety-five miles away. This city provides, through its wholesalers, nearly all the manufactured goods that Magugu buys. In turn, it is the main market for the excess agricultural products of Magugu.

represents 90 per cent of the maintenance work on this important road. Negley Farson in his controversial book, Behind God's Back, describes his experiences on the Great North Road in the vicinity of Magugu:

> The road, therefore, up through Tanganyika, is lonely. This is the Great North Road which runs from Capetown to Cairo.
>
> The best way to describe it in the rainy season, is to say that when you step out of your car, you slide. You slip, you slither. And, if you try to right yourself too abruptly, you come down on your behind. The red, buttery mud is as jellified as the bed of an English estuary at low tide, a duck marsh. Your feet weigh tons. You drive with chains, to get a grip. And when, in spite of chains, you find yourself sliding inexorably into a drainage ditch, you stop. Then you get out and take an axe, a shovel, and four burlap gunny sacks from out the back of your car. You go into the thorn woods and strike down a tree; you chop off its branches. You return, and with the shovel, dig out the submerged rear wheels of your car. You lay a small corduroy road of branches before each tyre; and over these you lay the burlap bags.
>
> Then you get back into your car, murmur a short prayer, and gradually let the clutch in. If the wheels grip, you're all right (for the moment); you're back on the crown of the road. But, usually, the churning wheels just grind your improvised road into the red mud under you...and you build again.
>
> That is why even the poorest white settler in Africa will never travel without a "boy". And there is no white man too poor to have one.[1]

Communications.--In addition to the lack of good highways Magugu has no fast communications with any other part of the world. There is neither telephonic nor telegraphic services, and mail is delivered only once a week. Even this mail

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[1]Farson, Negley, Behind God's Back (London: Victor Gollancz, Ltd., 1941), p. 142.

service is not Government-financed, but is what is known as a "Private Bag" service maintained by one of the local Indian traders. All mail is delivered to his shop, and in return for this service each subscriber pays him a yearly fee, and he in turn reimburses the Government.

As a result of this lack of communication the only fairly fast and feasible method of communication for the Europeans is the automobile. However, the African must either walk, cycle, or make use of an inadequate bus service which operates on the Great North Road, when it is passable (Figs. 59 and 60). Consequently in such an emergency as a gang robbery which occurred in Magugu in early 1954, the police arrived a whole day after the event. In the meantime the robbers had fled, and months after the crime they had not been found (Fig. 61).

Added to such unforeseen, but normally expected, incidents as health emergencies, is the important fact that transport is so expensive for the hauling of products from Magugu to markets in Tanganyika that until this problem is solved, Magugu can never expect to compete with other areas more favorably located in East Africa. Once, however, regular and reasonably priced transport is available for Magugu-Arusha shipment, Magugu would be able to ship efficiently to Arusha where there are direct rail links to both the ports of Tanga and Mombasa, which are ports of call for nearly all east coast shipping. Hence, the present isolation of Magugu can

Fig. 59.--A Magugu woman. The main method of transportation for the African is still by foot, but the small children get free rides. In the background are Wambugwe homes.

Fig. 60.--A fortunate few possess a bicycle. Note the two signs advertising gasoline. In 1954 there was a gasoline price war at Magugu, and gasoline could be purchased cheaper at Magugu than in Arusha, even though it was trucked in barrels from Arusha to Magugu.

Fig. 61.--A lineup of suspects in the Magugu robbery. This lineup, because of poor communications, happened months after the crime.

only be overcome by developing good roads and creating an adequate telephone-telegraph service (Fig. 62). When these steps are accomplished, it would most likely follow that electricity would then be introduced.

Until these public services are available, the present isolation of Magugu will continue. The airplane may in time play its part in overcoming these locational difficulties, but when one realizes that the important airport at Tanga still uses grass runways, it would appear that Magugu cannot expect efficient air service for a long time to come.

Climate.--Magugu, 4° south of the equator and 35° east of Greenwich, pays for the beauty of its site and the gentleness of its topography, with the effects of a poor location and of a climate that is far from ideal. Unfortunately, precise climatological data of Magugu are lacking. There is no meteorlogical station at Magugu, and the only stations compiling any weather information at all are more than ten miles away.[1]

As a result, much of the climatic data for Magugu must depend upon its reputation in the minds of Government officials,

[1]Even these stations are concerned entirely with rainfall and have no records of such vital data as temperatures, humidity, winds or cloud cover. The nearest station keeping what might be called a type of comprehensive weather information is Mbulu, twenty miles to the northwest. But Mbulu is outside the valley, and nearly fifteen miles west of the Rift Wall. The figures at such a station, thousands of feet higher in elevation, with all factors radically different from those in Magugu would be useless, for conclusions based on such material would have no reliability.

Fig. 62.--The Magugu-Sino Road. During the wet season it is impassable. Note the height of the grass along the road. It is not unusual to meet big game on this road.

farmers, and visitors. Rainfall figures are available for Madukani, ten miles to the north and in the Rift Valley. In addition, one farmer at Magugu, Mr. George Combos, at one time maintained a rain gauge, and though these records have since been destroyed, Mr. Combos stated from memory as much detail as such a method of obtaining information permits.

From the data of the Madukani station and from local farmers one can say that Magugu experiences a dry season from June to October inclusive (Fig. 63). Occasionally an inch or less of rain might fall in either June or October, but generally there is no measurable precipitation during these five months. April and March are the wettest months with a secondary maximum in December.

A few sample months as well as sample years may make clearer the rainfall regime at Magugu. The wettest year since records were first kept at Madukani (starting in April, 1939) was 1951 (Fig. 64). In that year 45.08 inches of rain fell, but even in this wettest year the average conditions held up. No rain fell at all in June, July, August, and September, while October had 1.07 inches that fell the last week of that month. April, with 19.67 inches of rain, surpassed any other month by a good many inches, and December with 8.73 inches was second in quantity. In looking at the opposite extreme, the driest year, 1943, we find that again April was the wettest month (Fig. 64). December, however, was an extremely dry one, only 0.18 inches falling. January, when it was hoped

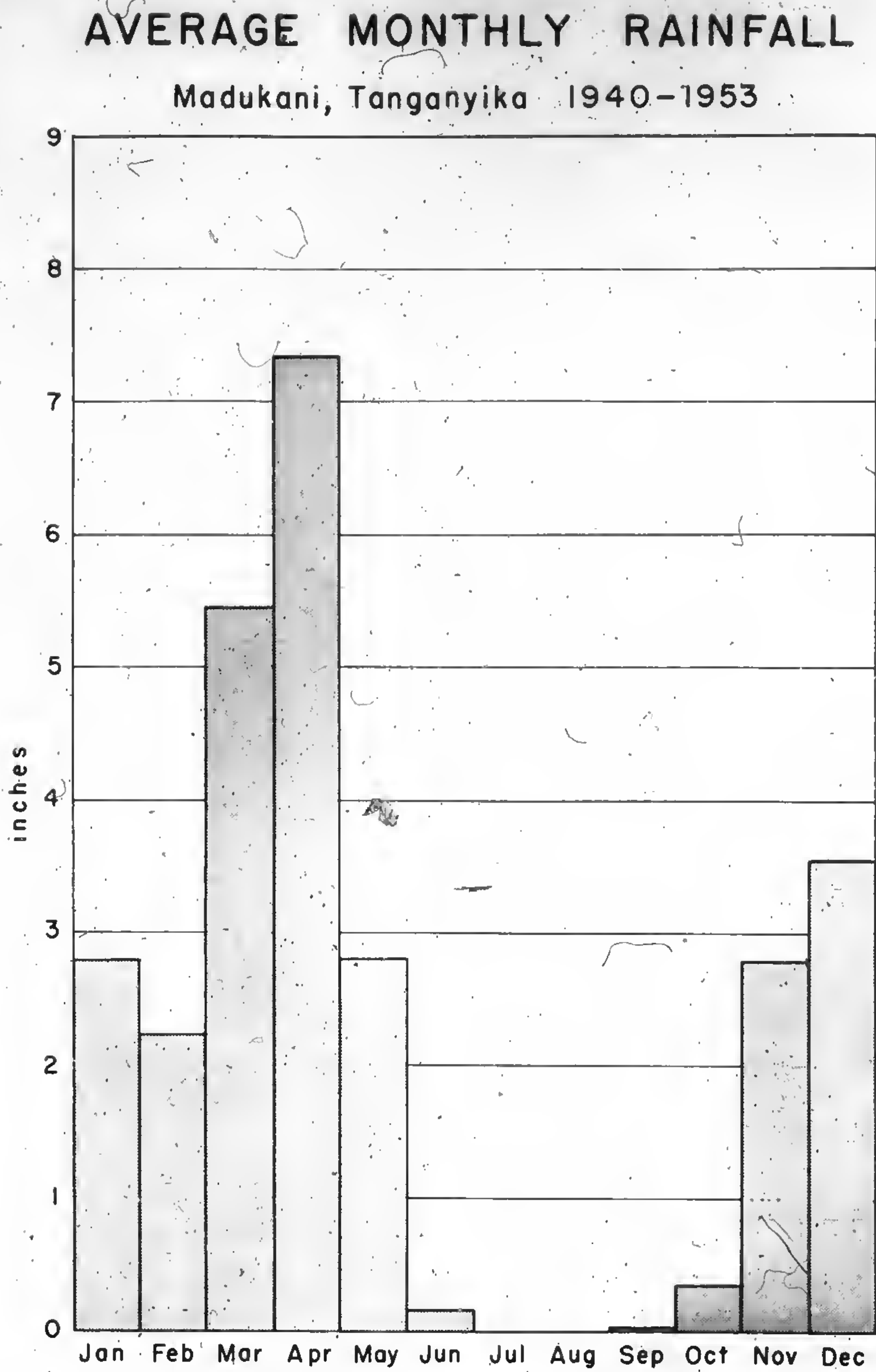
AVERAGE MONTHLY RAINFALL
Madukani, Tanganyika 1940–1953
inches
9
8
7
6
5
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Fig. 63

MONTHLY RAINFALL DURING DRIEST YEAR AND WETTEST YEAR

Madukani, Tanganyika

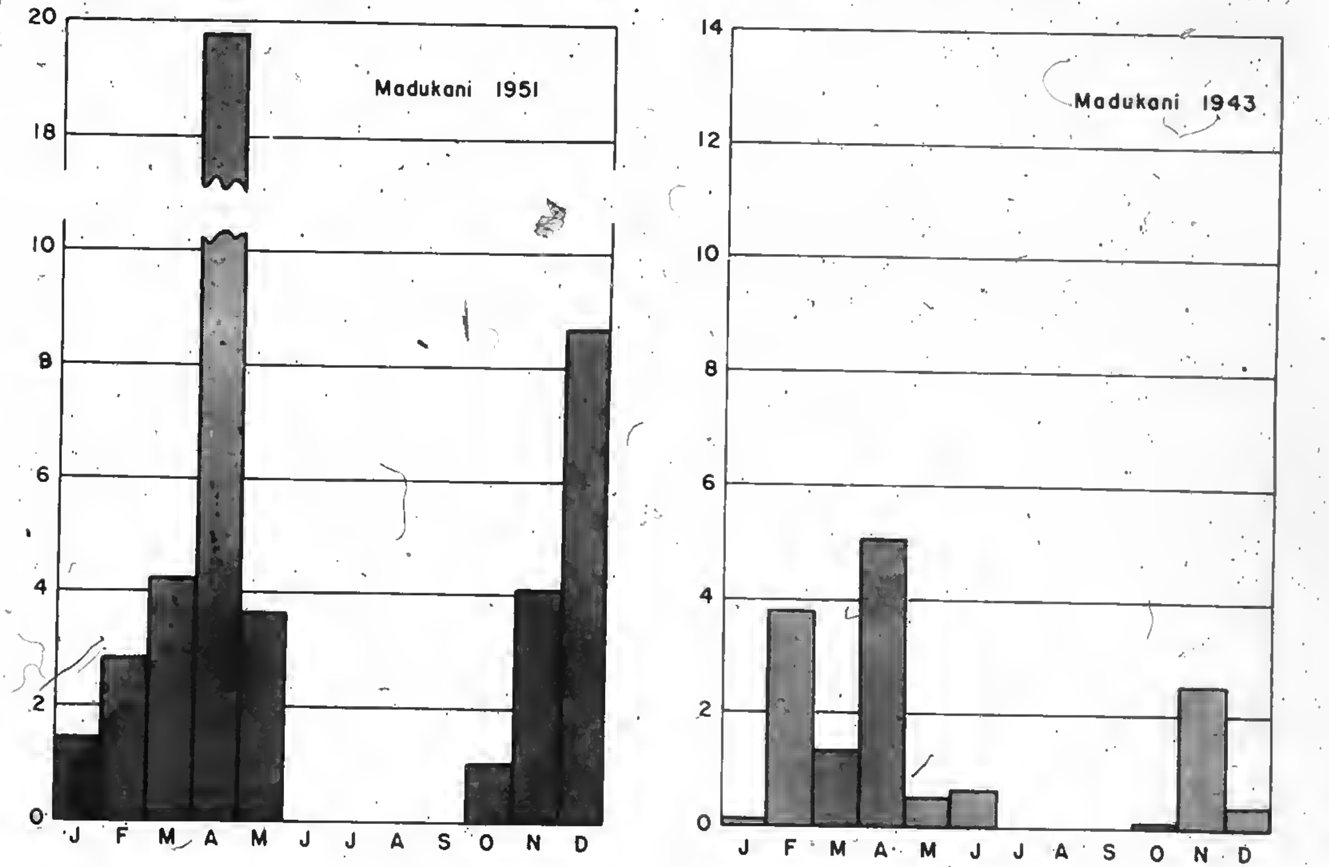

Fig. 64

the delayed December rains would fall, was also extremely dry with only 0.12 inches. However, February was the second wettest month of the year, though it only received 3.80 inches. Since 1939 April has been the wettest or second wettest month of the year twelve times. December has been the second or third wettest seven times.

One other set of rainfall figures for this area is available. These figures have been kept by a European farmer living on one of the Dudumera estates, just five miles south of Magugu at an elevation two hundred feet higher than Magugu. These records cover approximately four years, 1951-4. As Magugu is located between Dudumera and Madukani, these records provide a check for those of Madukani (Fig. 65). In 1951, 42.90 inches fell at Dudumera as against 45.08 inches at Madukani, and again April and December were the wettest months. In 1952, 24.56 inches fell at Dudumera as against 31.38 at Madukani. April at both stations was again the wettest month, and at both stations March was the second wettest month with December receiving little rainfall at both places. Greater variations appear in 1953 when the wettest month at Madukani was December with 5.78 inches, while Dudumera obtained only 3.28 inches in December and March, with 5.92 inches, was the wettest month. However, the pattern of distribution at both stations is much the same in this year as well, for at both stations the three wettest months were March, April and December, and at both stations there was no rainfall whatsoever

TOTAL YEARLY RAINFALL

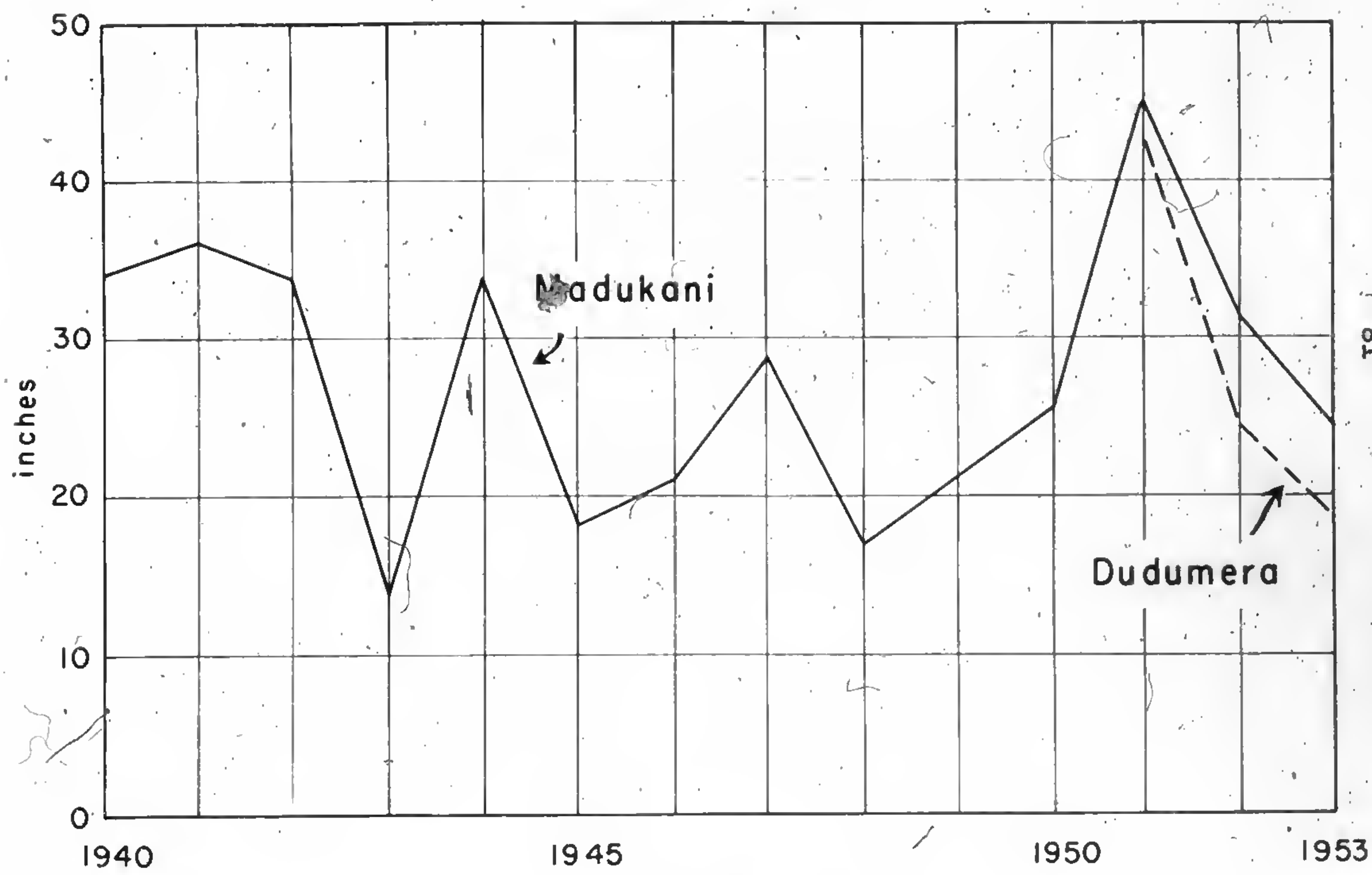

Fig. 65

during the period June-October. Hence, though there are no rainfall figures available at Magugu itself, it would appear from the correlation of the Madukani station with the figures at Dudumera that there normally would be some variations at Magugu as against either or both of these stations, but such variations would be slight. From these two stations one can assume that the average yearly rainfall at Magugu is about twenty-eight inches.

Perhaps the most distressing element of the rainfall regime is its unreliability (see Fig. 65). In 1940-41-42 over thirty inches fell each year. Then in 1943 only fourteen inches fell. In 1944 it was more than thirty; in 1945 only eighteen. In 1948 and 1949 there were respectively seventeen and twenty-one inches; in 1950 twenty-five inches; in 1951 nearly forty-six inches.

An equally disrupting element of the rainfall regime is the variation in what the ~~local~~ farmers choose to call the "short rains" that normally fall in January, February and March. Though these expected rains do not contribute greatly to the sum total for the year, they are vital to both European and African farmers, for it is during this period that the important corn crop is planted and starts its early growth.

To the African, the failure of rains at this time often spells crop failure, and to the European it means resorting to expensive irrigation. Some Africans also irrigate corn and thus reap a crop during dry years, but most African

irrigation is devoted to rice, sweet potatoes and specialized crops, such as onions. However, the millet crop is never irrigated, and since it plays such an important role in the African's economy, the failure of these short rains means the difference between a good year and a bad one.

A year like 1942 was one in which the rains in January and February were very light, but by March enough had fallen to insure some kind of a crop. The following year, 1943, January had only 0.12 inches and March only 1.37 inches. February, with 3.80 inches, would have been a normal month had not the previous and following months been so dry. In 1946, February had only 0.09 inches of rain, not enough in equatorial latitudes really to affect plant growth. Again in 1947 February had less than 1½ inches of rain. In 1950 both January and February had less than 1 3/4 inches of rain. And in 1953 and 1954 February was so dry that the amount that fell was barely measurable.

The significance of these figures can be highlighted by a description of what happened to the corn and millet crops in 1954. Heavy rains fell in January---nearly nine inches. The corn and millet crops sprouted well and reached good heights. Then in February when the plants should have had much moisture to form grains, less than 1½ inches fell. March, which often gets from five to ten inches of rain, was also dry---only 2.26 inches. As a result, by the time the April rains began the corn crop was nearly ruined. Unless water was applied by

irrigation, the beautiful fields of early January had become blackened and withered stalks. Even millet, which is the African's answer to drought, had done badly, and though the April rains still did the millet some good, the yield was far from a normal one.

Magugu, located in the bottom of a narrow valley only four degrees from the equator, has a high amount of insolation and thus needs much more moisture to produce a crop than if it were in a more temperate region. Furthermore, the balance between high and low yields is a very fine one. A rain at just the right time is so much more important than three rains in rapid succession when moisture is not needed. The only way one can determine this optimum moment needed for rainfall is by the condition of each individual field---a variation which is great within one farm; very great between more than one farm considering each farmer's ideas on when is the best time to plant; and greater still between one year and the next.

An added factor, that of the amount of cloud cover, has much to do with rainfall effectiveness and crop production at Magugu. A small rain followed by cloudy weather does much more good than a heavy one followed by brilliant sunshine, as is also the case elsewhere in the world.

As there are no temperature records available for Magugu, the only method avilable for determining the influences of temperature, as well as actual temperatures themselves,

is that of word of mouth. The European farmers at Magugu, one of whom has lived there continuously since 1935, will tell you that it never gets cold, night or day, winter or summer. In fact, they will insist that it never gets cool, and this can be attested to by the fact that many of the houses have all of one side entirely open to the elements, other than for screening. There are no fireplaces or heating appliances in any Magugu home. During the months of January through May, 1954, the temperature never fell below 65°F. and during January and February, the summer months, it always rose to over 100°F. by mid-afternoon. A single light blanket is all that is usually needed for sleeping at Magugu, and many are the nights that no covering at all is needed. However, as in many semi-arid tropical areas, it never really stays hot at night, and one is usually able to get a good night's sleep. To wear a light jacket in the early morning hours, before the sun's rays have had ~~much~~ effect, is not unusual during the winter months.

Humidity at Magugu has not been measured, but sensible humidity, i.e. how one feels, can be reckoned. One seldom feels the sticky clamminess prevalent on the coast, and even during the rainy season one is not oppressed by the seeming "closeness" of the weather. Since rainfall, for a tropical region, is quite low and insolation quite high, one may assume that humidity is generally low. It is seldom that fog surrounds Magugu---either it rains or the sun shines---there is little in-between condition.

Wind velocity and direction, like humidity and temperatures, have never been compiled in this part of the Rift Valley. Because Magugu is at the bottom of such a deep and narrow north-south valley, it is often spared strong drying winds from either east or west, but it also does not receive the cooling breezes from these directions during the hot months. Hence, wind patterns are developed on the north-south basis.

During the months of November-March the winds generally blow in from the northeast as the result of a low pressure area centered over central Africa. These winds, known as the northeast monsoons, come in over the dry Masai Steppe, and although the Steppe gets little moisture from them, when they are elevated above the western Rift Wall, Magugu experiences a period of light orographic rainfall. However, by July when a low pressure area is centered in Iran and central Asia, Magugu's winds come in from the southwest and are a combination of the southeast trades and the southwest monsoons. These moisture-bearing winds coming in from the Indian Ocean bring Magugu its main rainfall of the year. Hence, April is usually the month of maximum rainfall. However, Magugu is far enough inland so as not to feel the full force nor the long persistency of either of these winds. As a result there are months at Magugu in which there seems to be no wind at all---there is no pattern---slight breezes, "dust devils", or complete calm is characteristic of much of the time. Because of these conditions Magugu often suffers from oppressive heat while

above the Rift Wall breezes make living more bearable. But it also has its advantages: swarms of locusts, often following the winds, blow over Magugu from east to west, or remain on top of the Rift when the north-south winds are strong. Between January and May, 1954, four large swarms of locusts were observed on either the tops or sides of the Rift Wall, but none ever came down to Magugu---it was necessary to climb the wall to get a single specimen of these insects.

Vegetation.--Fortunately the vegetation at Magugu had been mapped by the Department of Tsetse Research before the clearings took place. In 1943, before the clearing operation, the survey revealed that from the present Sino Estate to the present alienated Magara area the timber consisted, in order of merit, of the following: (1) *Acacia Xanthophloea*; (2) *Acacia Campylacantha*; (3) *Acacia Seyal*; (4) *Acacia Nefasia*; and (5) *Acacia Usamberensis* (Fig. 66).[1]

In the area bordering the great Tindiga Swamp to the west of the present Magugu alienated farms, these types of trees tended to form a thicket, traversed only by game paths (Figs. 67 and 68). The remainder of this area consisted of regeneration of areas previously cleared by Europeans or Africans in an earlier battle against tsetse encroachment. The above-mentioned report suggests that:

It is more than apparent on careful analysis of the

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[1]This survey was conducted by Capt. A. G. H. DuFrayer, Provincial Tsetse Officer, Department of Tsetse Research, Arusha, in December, 1943.

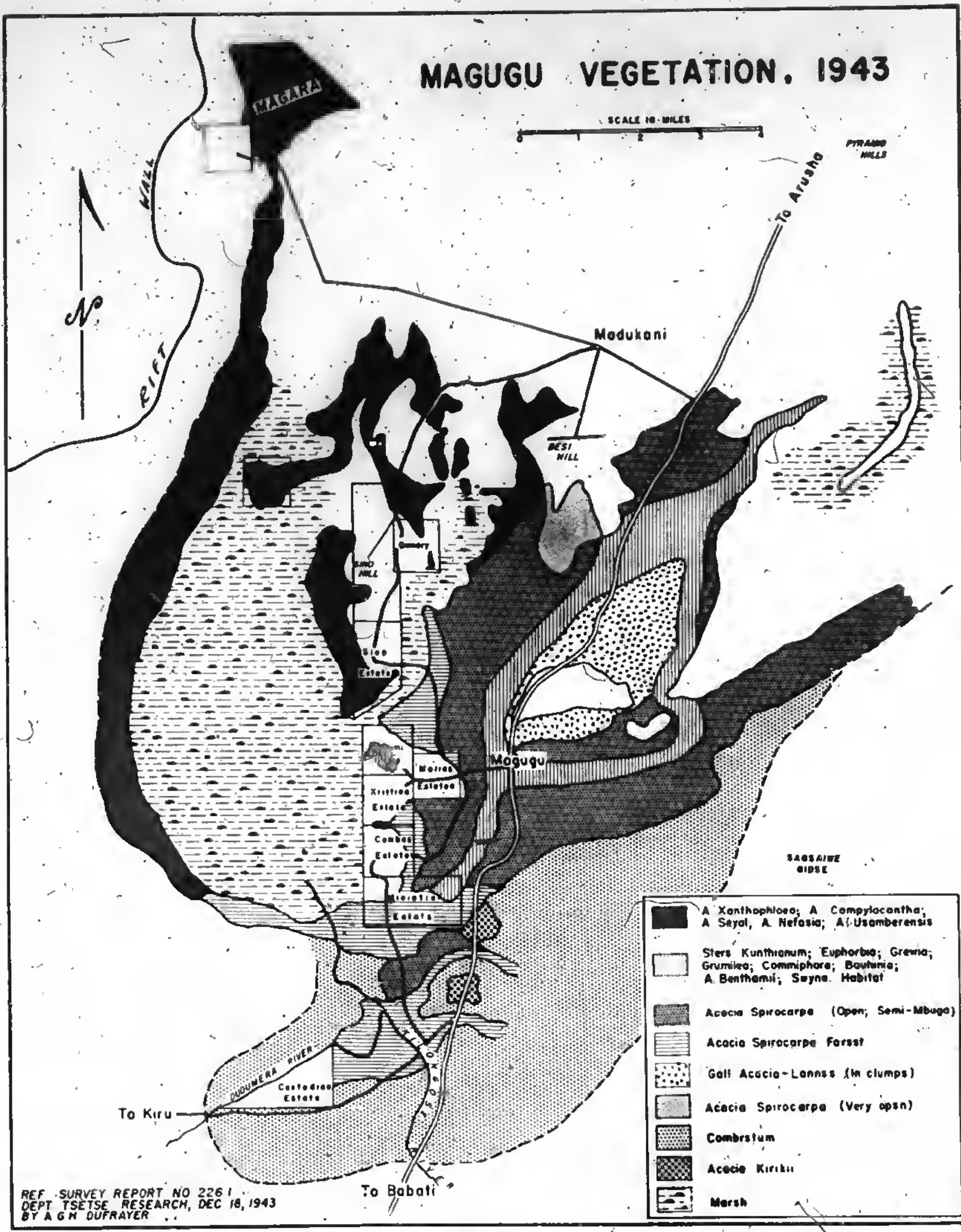

Fig. 66
(Note: The white areas within the Magugu area indicate European cultivation where labeled "Estate". Elsewhere they indicate areas subject to flooding which contain grasses during the dry season.)

Fig. 67.--Vegetation west of Sino Estate that has never been cleared. The tree in the foreground, a Kigelia, is commonly called a "sausage tree", so named because of its peculiar shaped fruit. The "sausages" are a favorite food of the rhinoceros.

Fig. 68.--Riverine vegetation west of the Tindiga Swamp. In the center of the photo on the edge of the sand bar can be seen a hyena. The hyena blends so well into the vegetation as to be nearly invisible.

> vegetation that year by year, and step by step, the fast growing A. Xanthophloea reputed to have a growth of up to six feet a year on favourable soil, is taking its steady claim on the mbuga system.[1]

Hence, we can assume that the large areas devoted to regenerating Xanthophloea at present had at one time a different vegetation that, because of man's clearings, has not been able as yet to reassert itself over the fast-growing Xanthophloea (Figs. 69 and 70).

This survey report divides the vegetation of the "mainland" part of Magugu into three parts: (1) the territory north of a parallel line drawn from east to west through Besi Hill; (2) the central sector, i.e. south of Besi Hill to an east-west line drawn through the present Kinyume estate; and (3) all the remainder south of Kinyume estate.[2] In addition, one other, and most important, classification is recognized: namely, that part of Magugu in which the species of tsetse, Glosinna Swynnertoni lives, and this area cuts across the previous three divisions. The Swynnertoni area of habitat forms nearly a circle with a long appendage on both the northeast and southwest ends (Fig. 66).[3] The vegetation harboring Swynnertoni consisted of Stereospermum Kunthianum; Euphorbia Bilocularis; Grewia-Pachycalyx; Grewia Bicolor;

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[1]DuFrayer, Capt. A. G. H., Tsetse Survey No. 1, Ref. No. 226.1 (Arusha: unpublished manuscript, Dec. 18, 1943), p. 2. The report was directed to The Survey Entomologist of Arusha, and its purpose was to ascertain the presence of certain species of tsetse fly in the Magugu area.

[2]The "mainland" idea is the result of most of Magugu being separated from the Rift Wall by the large Tindiga Swamp.

[3]So named after a former game warden of Tanganyika, Swynnerton, who has written extensively on the tsetse fly.

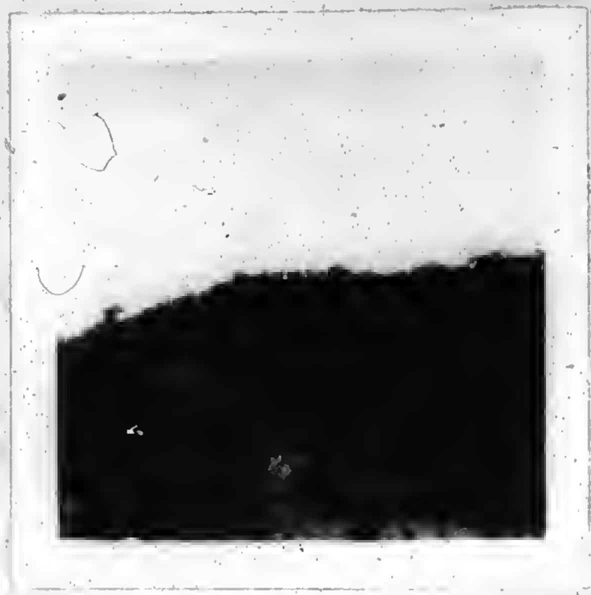

Fig. 69.--Regenerating <u>Xanthophloea</u> near Sino Hill.

Fig. 70.--The Burungi <u>mbuga</u> with various species of Acacia. In the center can be seen a group of ostriches.

Acacia Benthamii; Bauhinia spp.; Grumilea Platyphlla; and Commiphora Schimperi.

This vegetation follows a sandy water shelf and at the time of the survey varied from dense thickets to semi-thicket clumps about fifty yards apart. In the center of the Swynnertoni habitat is an mbuga which is part of the Burungi mbuga stretching to Lake Burungi but actually forms a basin within a basin which has become a hard pan wooded by Gall Acacia-Lannea and some Acacia Kirkii in clumps about fifty yards apart (see Fig. 66). Also within the Swynnertoni habitat area and more or less surrounding it on all sides, and in places representing a type of semi-mbuga, was an area of open Spirocarpa (see Fig. 66). These areas were not very well drained, and the main species of vegetation was the Acacia Spirocarpa which had attained a girth of between fifteen and twenty inches, growing up to fifty yards apart and with an undergrowth of moderately heavy grass and some young trees of the A. Spirocarpa species.

To the west and southwest of this open Spirocarpa, the Spirocarpa was much more developed in size as well as thickness. The trees grew close together on rich soil with an undergrowth of heavy grass and hence were classed as Spirocarpa Forest. To the southeast of the open Spirocarpa is the clearly defined Combretum area. This is a low type of scrub in which the trees do not reach appreciable size, but they grow extremely close together with here and there a very

short grass undergrowth. Scattered within the Combretum, mainly along the Great North Road, small patches of A. Kirkii were found. In fact, throughout the woodlands of Magugu, species of A. Kirkii occurred in no set pattern.

The vegetation map therefore represents the pattern of vegetation that greeted the original clearers of Magugu. Some types were ideal habitat for the tsetse fly. Others were used by the fly only if nothing more favorable were to be found. Hence, there is a direct correlation between this original vegetation pattern and the stages of clearings discussed previously. The original clearings of 1944 were designed to wipe out the area labelled as Swynnertoni habitat (see Fig. 9, p. 19). Then in 1945 the "Burungi Pencil", represented on the vegetation map as a long tongue of open Spirocarpa, along with the open Spirocarpa area near the Dudumera River and the Spirocarpa forest at the southern apex of the Magugu triangle were cleared (Fig. 71 and see Fig. 24, p. 38). In addition, the large area of Combretum to the southeast was then cleared.

With this vegetation removed, Magugu, assisted by the natural barriers afforded by the Tindiga Swamp to the west and Lake Burungi and the Sangaiwe Ridge on the east, became a self-contained unit free from the fly. Because, however, fly could still be brought in by outsiders, and because Magugu still could not be used as a cattle route as long as the area around it was fly-ridden, the clearings

Fig. 71.--The beginning of the Burungi mbuga. In the upper right hand corner begins the mbuga. Between the mbuga and the Great North Road to the west was the "Burungi Pencil" which, when cleared, provided Magugu with an effective tsetse fly barrier on the east. In the lower left corner can be seen the clearing line running in a northeast direction. (Photo courtesy of Air Survey Division, Department of Lands and Surveys, Dar es Salaam, Tanganyika).

of 1946 removed the vegetation along the Great North Road to Babati-Bonga-Kisesse (see Fig. 34, p. 46). The regeneration of all this original vegetation forces continual reclearing of the bush surrounding Magugu (Figs. 72, 73, and 74). However, the original lines of clearing have remained essentially the same except for minor changes made to the extreme south by the expansion of the alienated Dudumera area.

Of course, the present vegetation at Magugu has been radically changed since the survey in 1943. Much of the area of former bush is now cultivated. The remainder is kept from regeneration by periodic clearings by Africans. As a result, the vegetation that exists outside the cultivated areas (but, of course, within the original cleared areas) is all of small size.

One untouched remnant of the previous vegetation remains, the baobab trees. Because of their tremendous size, many more than ten feet in diameter, and their small crown offering little shade to the tsetse, plus the fact that they are widely scattered, they were not cut (Fig. 75). These giants not only provide a place of shade and rest for animals and humans but, because they can be seen for miles around, they also act as points of measurements in determining land allotments and disputes. However, the rest of the vegetation is now strictly "bush"---small scrub thorn, much of it <u>Acacia Mellifera</u>, offering an occasional

Fig. 72.--A semi-mbuga with clumps of regenerating Spirocarpa.

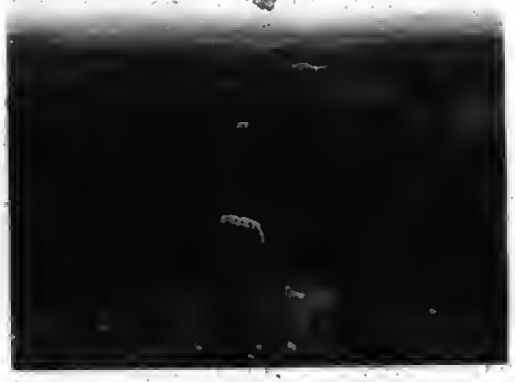

Fig. 73.--Northeast from Sino Hill showing the regeneration in the valley.

Fig. 74.--Giraffe on the open park-like grazing grounds on the eastern side of the Burungi _mbuga_. Though the _Acacia Spirocarpa_ has grown quite tall since the clearings of ten years ago, it is not dangerous for tsetse encroachment because of its lack of density.

Fig. 75.--A remnant of the Magugu clearing, a baobab tree. Note the size of the trunk. A full-grown man is standing at its base.

leaf to an ambitious goat, and permitting the growth of some grasses that are utilized by the Africans in grazing their cattle and sheep.[1] Indeed, the human wandering through the Magugu bush would not only be hard-pressed to find some shade but to find it he also would have to crouch close to some small bush, and in so doing he would most probably find he could not sit down because of the mantle of thorns shed by the bush. This present degraded type of vegetation is, of course, a direct result of the clearing operations, and because of the indiscriminate clearing that was done it is now hard to find wood at Magugu for either fuel or building purposes. Hence, it is a common sight to observe the smoke from charcoal fires rising from the slopes of the uncleared Rift walls, because the African must risk sleeping sickness infection, prevalent in the uncleared areas, if he is to find adequate fire wood or timbers for building.

Soils.--Prior to the clearing of the existing vegetation, one might have presumed that it would have been possible to use the vegetation as a guide to soil types at Magugu. However, an attempt to correlate soils in 1954 with the vegetation of 1943 reveals that much of the vegetation of Magugu had small concern for, or indeed need of,

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[1]Acacia Mellifera has a popular and descriptive name of "Wait-A-Bit-Thorn", so called because when one hooks his clothing on it the thorns are so tenacious that one must, of necessity, stop and patiently disentangle his clothing.

specific soil types. Such hardy types as the acacia species seem to cut indiscriminately across soil boundaries. At the present time, with the changes made by man in the last ten years, vegetation not only cannot serve as an adequate guide, but also in many instances African-induced vegetation has been introduced seemingly without regard to soil types. Therefore, as a basic foundation from which to work and as a starting point from which many phases of land utilization might be understood, an intensive investigation was conducted into the soils of about fifty square miles of the Magugu area (Figs. 76, 77, 78, and 79). For such a comparatively small area, Magugu contains an unusually wide variety of soil types. Field study of their origin and genesis reveals the reason for their many differences and the cause of their complex distribution. Complementary laboratory investigations show that the properties of these soils markedly affect the present land use pattern.[1]

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[1]Mr. John W. Vail, Soils Chemist, was mainly responsible for this soil survey which was made at the request of the author, but could never have been made without Vail's assistance. He brought along a qualified African assistant, hired Africans to dig pits, rented tools, provided a truck, shipped the soil samples back to Dar es Salaam, and saw to it that they were properly analyzed in the Government laboratories. In addition, he is the author of a twenty page report giving the results of this work and has drawn two maps of soil distribution at Magugu. In collaboration with the author, soil pits were named after the African names for the area in which they were dug, and profiles were made and photographed by the Public Relations Department of the Tanganyika Government in June, 1954. It is from this work and the resulting Vail report that the soils information in this study has been obtained, and the author expresses his appreciation to Mr. Vail for his assistance in this important matter.

Fig. 76.--One of the pits dug during the soil survey. The assistant is measuring the depths of the various soil horizons which are being recorded in a note-book by Mr. John Vail, Government Soils Chemist. The box contains bags of soil samples.

Fig. 77.--Filling bags with soil samples.

Fig. 78.--One of the soil pits. Note the depth of this pit and those appearing in other photos. All pits were over six feet deep and wide enough to allow a man to get proper soils samples.

Fig. 79.-- Trimming a soil pit for measuring horizons. An African assistant, who is in training to become a soils chemist, aided in the soils survey.

In order to determine the origin of these soils it is necessary to understand something about the geomorphology of Magugu. The two salient features in the geomorphology of the area are the Rift Valley faulting with its concurrent volcanic activity, and the post-Rift growth and decline of Lake Manyara. As previously mentioned, the west wall of the Rift forms a sharp boundary on one side with a sheer escarpment rising over three thousand feet, whereas to the east the land rises more slowly to an ill-defined wall bordering the Masai Steppe. At Magugu a a more or less pronounced but local "wall" is supplied by the Sangaiwe ridges. The rocks of these walls and of the floor of the sunken Rift Valley are basement complex gneisses of great geological age. To the south, the floor of the Valley rises abruptly in the Babati area and is characterized by a region of former intense volcanic activity centered around the now extinct volcanoes of Mt. Hanang and Mt. Ufiomi (also called Mt. Kwaraha). It is also possible that localized volcanic extrusions occurred along the Rift faults, but evidence on this point is not certain.

The natural drainage therefore, once the Rift faulting had taken place, was from south to north and from east to west with the west Rift Wall forming a dam of phenomenal proportions to both these drainage flows. In this way Lake Manyara came into being. The southern end

of the Lake Manyara region thus has two distinct catchment areas: to the east the hills composed of the largely acidic and base-poor gneisses and to the south from the hills which are both gneisses and volcanic, the latter being highly basic and more readily weathered than the gneisses.

In the past, presumably during a pluvial period, Lake Manyara was much bigger than it is today and did in fact cover the whole of the Magugu area other than for a few outcroppings such as the present Sino and Besi hills. With drier conditions, and the gradual filling up of the lake basin with water-borne material from the surrounding hills, the lake shore line receded, leaving behind great stretches of flat partially-consolidated lake bed deposits. These lake bed deposits have given rise to one large group of soils in the area and have been named, for this study, the Manyara Lacustrine Series (Fig. 80).[1] As the lake level fell still further, with a corresponding lowering of the drainage outlet, some resorting and weathering of the lake bed types occurred, filling in pockets with finer textured soils and forming the group named the Magugu Mbuga Clays. By this time the floor of the valley was almost flat, with a relief probably very similar to that which exists today. Over this flat plain the streams from

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[1]The names given by the author to the Magugu soils are descriptive of both the area and the soil formation process. Hence, Manyara refers to the local lake and lacustrine to its lake origins.

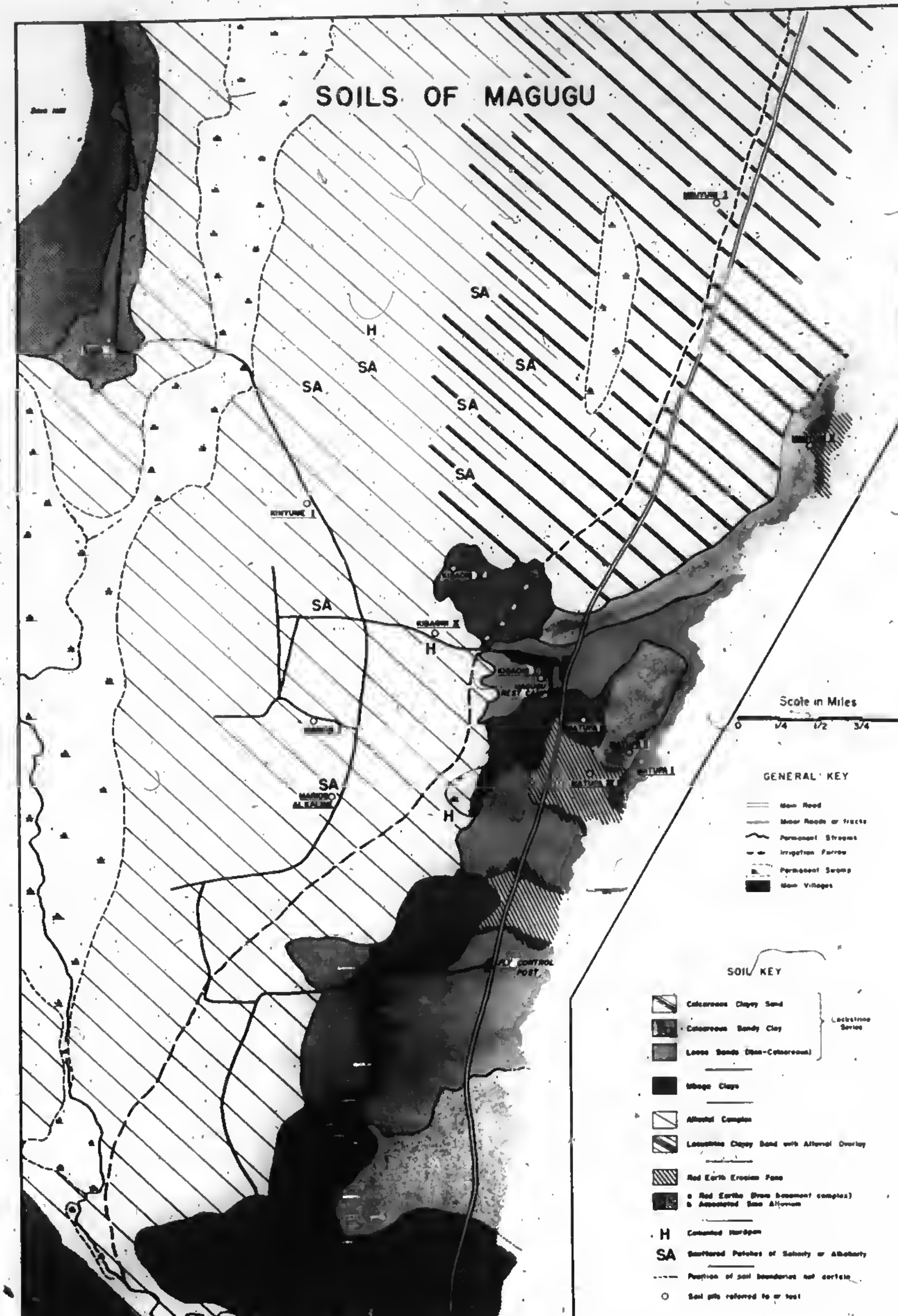
SOILS OF MAGUGU
SA
H
Scale in Miles
0
1/4
1/2
3/4
1
GENERAL KEY
SOIL KEY
H
SA

Fig. 80

the surrounding hills have spread out their loads of clay, silt, sand and rock fragments in a complex pattern of fans and deltas. This process, of course, is still going on today.

Because the land is now almost entirely flat, many of the streams and underground seepages evaporate before reaching the lake proper, depositing in the process their soluble constituents. This effect naturally becomes more pronounced to the north of the area, nearer the present lake shore. The texture and depth of these recent deposits vary with the strength of the stream that gave rise to them. Furthermore, the material deposited varies from highly micaceous silts and sands, derived from basement complex gneisses, to fine gritty sands derived from lavas or pumice. This whole group of soils derived from recent water-borne deposits has been named the Magugu Alluvial Complex.

As the Rift faulting in this area is considered to have taken place in Pleistocene times at the earliest and the lake bed deposits are Recent, all the soils are comparatively young and, unlike the soils in many parts of East Africa, still bear quite clearly the imprint of their parent materials.

The large classifications of the Magugu soils are further divided as to types. The Manyara Lacustrine Series is divided into (1) calcareous clayey sands; (2) calcareous sandy clays; and (3) loose sands (non-calcareous).

Chronologically these are the oldest soils in the area. The Magugu Mbuga Clay Series, which have been formed by weathering from the lacustrine series, have not been distinguished by types, but the Magugu Alluvial Complex is divided into (1) gritty silty clays; (2) sandy clays; and (3) skeletal erosion detritus. These types of the alluvial complex are further divided into a number of phases such as the saline phase and the hardpan phase. These alluvial soils are all more recent than the lacustrine or mbuga clay series.

The oldest soils in the area are the Calcareous Clayey Sands, though this does not mean they are the most highly developed. They are derived from the material exposed as the lake receded and still exist over large areas to the north of the Magugu Rest Camp where they have been unaffected by post-lacustrine cutting down of drainage. The lake-bed materials are cemented calcium carbonate, containing much quartz sand and a liberal proportion of highly basic unweathered volcanic material. Like all the Magugu soils these materials have formed under a relatively dry climate (estimated rainfall now twenty-eight inches per annum), and in a region which is almost completely flat. They are only slightly developed shallow grey sands or clayey sands overlying heavier, highly calcareous clays which are to some extent saline. They support a fairly good grass cover, except where salinity is high, and on the

better drained phases a few Gall Acacia trees are regenerating after having been cleared in 1944-46.

In making the soil survey various pits were dug to a depth of over six feet. Certain pits, which it was felt were most characteristic of one of the soil types, have been chosen for discussion in order to show the various qualities of each type. Profiles of ten of these pits were made and photographed in Dar es Salaam, and these photos show the true color and texture of the Magugu soils (see Figs. 81, 82, 83, 84, and 85). In addition, such factors as salinity, organic carbon, phosphorus and exchangeable calcium were determined in the Government Chemist's laboratories in Dar es Salaam. One such pit, representing the calcareous clayey sands, was the Mbuyuni I Soil Pit (Table I and Fig. 81).

TABLE I

MBUYUNI I SOIL PIT[a]

Depth (inches)	Conductivity (micromhos/cm)[b]	pH	Free Calcium Carbonate
0-4	45	8.7	Nil
4-22	590	10.9	Positive
22-60	1150	10.2	Strongly Positive

[a]The titles of these pits refer to the localities in which they were dug.

[b]These standard units are used throughout to express conductivity.

In this pit there was a shallow topsoil of loose grey sand, only slightly coherent, over a brownish grey slightly clayey friable sand, over a pale yellowish grey, gritty, friable sandy clay which becomes more consolidated with depth.

The Calcareous Sandy Clays are soils in effect transitional between the clayey sands discussed above and as represented by the Mbuyuni I pit and the next main group, the <u>mbuga</u> series. That is, they are lake-bed soils which have been only slightly affected by post-lacustrine weathering. They therefore occur only on the slightly higher lying areas of the lake-bed flats where, in the rainy season at least, there is a gradual depletion of minerals through leaching of water. They have a higher clay content but in other respects they are very similar to the previous types. A good example of these soils was found in the Matufa II Soil Pit (Table II and Fig. 81).

TABLE II

MATUFA II SOIL PIT

Depth (inches)	Conductivity	pH	Free Calcium Carbonate
0-4	220	9.4	Strongly positive
At 24	500	10.0	Very strongly positive
At 36	700	10.0	Strongly positive

The profile of this pit may be described as having a tough, dark-grey, sandy clay, which cracks on drying, over

a gritty, sandy clay. This lowest layer contains a calcium carbonate coated rubble of consolidated lake-bed material which has a very high content of lava grit.

On the eastern edges of the lake-bed flats, where the land rises fairly sharply towards the Sangaiwe Ridge, and also stretching out in the promontories over the flats are the third and final type of the lacustrine series, the non-calcareous Loose Sands. These probably represent old river deltas where incoming rivers deposited their coarser suspended matter just below the shoreline. Such deposits now appear as flat-topped ridges at intervals along the Great North Road, and the Magugu Rest Camp and the Kibaoni trading settlement are situated on such a ridge. A pit representing the Loose Sands and called Kibaoni I was dug close to the Rest Camp (Table III and Fig. 82).

TABLE III

KIBAONI I SOIL PIT

Depth (in.)	Cond.	pH	Free $CaCo_3$	Org.C.[a]	P.[b] p.p.m.	Ex.Ca.[c] m.e.	Color
0-4	131	7.9	Nil	2.3	35.5	9.5	Grey
4-16	196	8.3	Nil	0.4	8.7	6.7	Very dark grey
16-24	126	8.3	Nil	0.15	34.0	1.7	Brownish grey
24-34	125	8.3	Nil	0.08	26.0	1.3	Light brownish grey
34-40	111	8.3	Nil	0.03	21.0	1.5	Pale brownish grey
40-46	90	8.2	Nil	0.05	37.0	1.4	Almost white
46-58	142	8.6	Nil	0.03	40.0	1.7	Brownish grey-rust colored stains

[a]Percentage of organic carbon
[b]Phosphorus, parts per million
[c]Percentage of exchangeable calcium, milliequivalents

Fig. 81.--Soil profiles of Mbuyuni I and Matufa II Soil Pits.

Fig. 82.--Soil profiles of Kibaoni I and Matufa I Soil Pits.

This soil is a loose sand in all layers, almost entirely lacking in cohesion except for the second and lowest layers which have a very weak crumb structure. In all but the lowest layers the sand is fine, probably having been abraded by water action, and is white in color where free of organic matter, as is the case with the 34-46 inch layers. Swamp conditions may well have existed in these lake shore sands which might account for the bleached color of the lower layers, but there is no definite evidence on this point. The lowest layer is coarser in texture with a browner color derived from iron staining and fragments of unweathered rock. This pit was dug in a cultivated field.

The sands on these promontories have been left more or less "high and dry" but to the east of these ridges, where the sandy deltas spread round the fringes of the lake-bed flats, similar soils are found in which there has been some modification caused by their colluvial position relative to the Sangaiwe Ridge foothills. Such a soil was sampled at Matufa I Soil Pit (Table IV and Fig. 82).

This soil is a dark brown sand, only slightly clayey, uniform in color, and rather gravelly at its lower depths. It is loose and structureless down to thirty-one inches and below fifty-seven inches. Between these depths occurs a hardpan layer which is impenetrable

to ordinary hand implements such as a spade or hoe. The cause of this hardpan layer will be discussed later on in this report.

TABLE IV

MATUFA I SOIL PIT

Depth (in.)	Cond.	pH	Free $CaCO_3$	Org. C.[a]	P.[b] p.p.m.	Ex. Ca.[c] m.e.
0-23	28	7.0	Nil	0.15	27.0	4.2
23-31	49	6.9	Nil	0.18	3.2	3.9
31-57	80	7.4	Nil	0.15	4.2	3.9
57-69	112	7.9	Nil	N.D.[d]	9.3	4.1

[a]Percentage of organic carbon.
[b]Phosphorus, parts per million.
[c]Percentage of exchangeable calcium, milliequivalents.
[d]Not determined.

The Matufa I soil type is found on the free-draining slopes east of the lake-bed flats and represents a slightly more developed soil than the Kibaoni I type. Its natural vegetation is <u>Miombo</u> woodland with fairly thick undergrowth.

The utilization of all the soils of the lacustrine series depends on a number of factors. The development of the most extensive members of this series, the clayey sands, will hinge on water availability and drainage. They receive no water other than by rainfall, but the local Africans snatch a crop from them at the onset of the rains before they become waterlogged. Large scale development for such a crop as rice will require irrigation,

and, in view of the high pH of these soils and their potential salinity, an effective drainage system will be essential under irrigation, but it is doubtful whether this is an engineering possibility in view of the flat topography. However, the soil itself is rich in bases and has a good reserve of plant nutrients (unweathered volcanic material), and it ought to be put to some use. Under present conditions their use as grazing lands seems the best method of exploiting these soils.

The heavier, sandy-clay type of the lacustrine series is of even less value for food crops, as it combines all the disadvantages of the previous type with a very difficult topsoil structure which cannot be worked at all by hand during the dry season. The Africans leave it alone. These soils are waterlogged during the rains, and again their chief value appears to be as dry season grazing grounds, though the extent of the grass is limited by patchy salinity or alkalinity.

The ridges of loose sand are all either occupied by dwellings or are farmed with such crops as corn, millet and cassava. These crops are grown with a degree of success that depends on the rainfall rather than the soil. Although of considerable value to the present African population, because they are easy to work and are sufficiently fertile for non-intensive agriculture, they do not represent an important type in the development of the

area as a whole. They are in most cases not irrigable, and the high pH and low exchangeable calcium levels indicate a poor ability to hold plant nutrients. Phosphate levels are adequate on the low-lying members but low in those higher on the slopes.

The Mbuga Clay Series is represented by two soil pits, Kibaoni III and Matufa III (Table V and Fig. 83).

TABLE V

KIBAONI III SOIL PIT

Depth (in.)	Cond.	pH	Free $CaCO_3$	P.[a] p.p.m.	Ex. Ca.[b] m.e.
0-6	470	8.9	Positive	73.0	N.D.[c]
6-18	85	7.9	Nil	68.5	8.2
18-48	1700	8.0	Positive	45.0	N.D.

[a]Phosphorus, parts per million.

[b]Percentage of exchangeable calcium, milliequivalents.

[c]Exchangeable calcium was not determined, but is presumed to be high when the soil is calcareous.

This is a deep, dark grey, calcareous, silty clay but with a gritty feel in the two top layers. Very tough and compacted in the top and lowest horizons, it has a massive structure in the field, but with a more friable, gritty, only slightly clayey horizon from 6-18 inches. This is most likely a recent overlay of mainly volcanic material.

In the Matufa III profile, which is shown in Table VI, the topsoil is discontinuous with the rest of the profile, being a brown, micaceous, clay-loam formed by erosion wash from one of the skeletal erosion fan soils

which is found on a nearby slope (see Fig. 85). Below this occurs the true mbuga clay: a very dark grey, tough, cloddy clay which is massive in structure when wet but which cracks vertically on drying. The lowest layer is a rather gritty, sandy-clay.

TABLE VI

MATUFA III SOIL PIT

Depth (in.)	Cond.	pH	Free $CaCO_3$	Org.C.[a]	P.[b] p.p.m.	Ex. Ca.[c] m.e.
0-6	78	9.4	Nil	1.4	33.5	16.1
6-16	114	9.1	Slight	0.87	35.5	15.4
16-39	282	9.6	Positive	0.69	17.0	N.D.[d]
39---	300	10.0	Positive	0.36	10.0	N.D.

[a]Percentage of organic carbon.
[b]Phosphorus, parts per million.
[c]Percentage of exchangeable calcium, milliequivalents.
[d]Exchangeable calcium was not determined.

The utilization of the mbuga clays presents such great obstacles that perhaps they will be largely unused in our time. The mbugas are flat grassland areas with sluggish surface and underground drainage. They are, however, much deeper soils than the lake-bed sandy clays. They have a fairly high base status as shown by the fact that exchangeable calcium and phosphorus levels are adequate, but they suffer from an intractable structure. This difficult structure is partly due to their more silty texture, but they are also likely to have high exchangeable sodium levels. The effect of a high proportion of sodium

in the exchange complex on the structure of Magugu soils is discussed in more detail at the end of this chapter. Conductivities tend to be high in these clays, particularly at depth, and in some cases, where there is no recent overlay, even the topsoils are saline, so that the grass cover is often very sparse.

It is probable that their difficult structure combined with their tendency towards salinity (the latter being responsible for the former) has prevented the local Africans from making more use of these soils. In fact, even modern methods could bring them under cultivation only at considerable expense, as it is most probably that, in addition to leaching with effective drainage to reduce salinity, chemicals would have to be applied to bring the exchangeable sodium content to more normal levels. This, of course, could be done, and potentially they are capable of being developed, as they are within reach of plentiful water supplies and topographically convenient for drainage schemes. But the expense of chemicals and drainage schemes makes the future of these soils problematical, and at present they are used only as dry season grazing grounds.

The Alluvial Complex covers the greatest areal extent of any of the Magugu soils. The origin of the recent alluvial soils has been discussed, and it follows from this that not only are they fertile, but they also contain abundant reserves of mineral fertility in the form

of unweathered rock fragments. The mineral reserve is commonly a mixture of volcanic and basement complex material, but in places patches of soil are derived entirely from one or the other. Much of the extensive area occupied by these soils is now permanent swamp, but where the soil is not waterlogged the natural vegetation is one of thick tall grass and clumps of acacia thorn. They are, with one or two notable exceptions which will be described below, of great agricultural value and respond to intelligent management.

An example of the deeper, more freely draining type was found in the Marios I Soil Pit (Table VII and Fig. 84).

TABLE VII

MARIOS I SOIL PIT
(GRITTY SILTY-CLAY)

Depth (in.)	Cond.	pH	Free $CaCO_3$	Org.C.[a]	P.[b] p.p.m.	Ex. Ca.[c] m.e.
0-3	90	7.5	Nil	0.6	29.0	17.6
3-21	60	7.5	Nil	0.4	34.0	12.7
21-30	140	8.9	Positive	0.3	25.0	N.D.[d]
30-48	55	8.7	Nil	0.1	111.0	7.3

[a]Percentage of organic carbon.
[b]Phosphorus, parts per million.
[c]Percentage of exchangeable calcium, milliequivalents.
[d]Exchangeable calcium was not determined.

The first twenty-one inches of this soil is a non-micaceous clay, only slightly cracking with a massive structure when

damp which, however, dries out to form hard crumbs. It is mainly volcanic in origin. From 21-30 inches there is a micaceous silty clay with a fairly tough cloddy structure. It is a weathering product of the next horizon. The bottom eighteen inches of this profile is a loose, micaceous silt of fine sand with fairly extensive brown mottling. Although the iron staining at depth indicates some waterlogging, this is a reasonably free-draining and developing clay soil. Rich in calcium and with good phosphorus reserves, non-saline, and only slightly calcareous it represents some of the best soil of this area and is put to intensive use by the local population, both African and European. It is used for coffee, paw paw, corn and millet. Under good management a stable loamy topsoil may be produced from this type.

Another example of recent alluvium with a different texture to the previous profile is shown by the Kinyume I Soil Pit (Table VIII and Fig. 84).

TABLE VIII

KINYUME I SOIL PIT
(SANDY CLAY)

Depth (in.)	Cond.	pH	Free $CaCO_3$	Org. C.[a]	P.[b] p.p.m.	Ex. Ca[c] m.e.
0-6	150	9.4	Slight	0.09	34	8.6
6-18	600	10.8	Positive	0.18	39	N.D.[d]
18-36	420	10.8	Slight	0.09	34	6.8
36---	450	10.8	Slight	0.18	40	1.6

[a]Percentage organic carbon. [b]Phosphorus, parts per million.
[c]Percentage exchangeable calcium. [d]Not determined.

Fig. 83.--Soil profiles of Kibaoni II and Kibaoni III Soil Pits.

Fig. 84. Soil profiles of Marios I and Kinyume I Soil Pits.

The topsoil of the Kinyume I profile is a dark grey, crumby, sandy clay, mainly of volcanic material, over a brownish-grey, very sandy clay. The 6-18 inch layer is tough and difficult to dig. The lowest layer is a coarse micaceous quartz sand. The raised conductivity level in the second horizon and the high pH's illustrate the one disadvantage to many of the soils in the alluvial complex. The alluvial soils lie, naturally, where streams still flow or tend to flow but in such a flat region the drainage pattern is complex and the flow intermittent. In numerous places underground seepages are halted or are forced to surface and evaporation takes its toll. The result of this is that the salinity of the soil is raised and sometimes the normal balance of exchangeable calcium to exchangeable sodium is reversed by the process of alkalization. Alkalization can and does turn a fertile soil of the Marios I type above into a tough, intractable hardpan soil of the type which is illustrated by the profile in the Marios Alkaline Soil Pit (Table IX).

The top five inches of topsoil in the profile in Table IX are a very dark grey, gritty clay followed in the next horizon by tough, cloddy, black, calcareous clay with a trace of mottling. The next layer is similar but has more of a sandy clay in texture. The 35-42 inch layer is a clayer micaceous silt, easy to dig and quite structureless, whereas the final eight inches of this pit are a

structureless micaceous medium sand with a brown color.

TABLE IX

MARIOS ALKALINE SOIL PIT
(GRITTY SILTY CLAY-ALKALINE PHASE)

Depth (in.)	Cond.	pH	Water Soluble Sodium m.e.[a]	Ex. Sodium m.e.[b]	Ex. Capacity m.e.[c]	Ex. Sodium As percentage of ex. Capacity.
0-5	300	9.4	3.1	9.3	16.1	58
5-19	350	10.0	3.8	23.8	18.3	100
19-35	290	10.0	3.0	12.3	14.1	87
35-42	250	10.3	1.9	9.3	18.9	49
42-50	120	9.3	1.1	10.0	38.9	26

[a]Percentage, milliequivalents.
[b]Percentage, milliequivalents.
[c]Percentage, milliequivalents.

The Marios Alkaline Soil Pit was dug in an area that was quite devoid of grass though surrounded on all sides by crops or abundant grass cover growing on the Marios I soil type. Despite the deceptively low conductivities (i.e. below the figure five hundred, considered to be the lower limit for a saline soil), the figures for exchangeable sodium reveal the highly alkaline nature of this soil. The quantity of sodium present does not determine the properties of an alkaline soil so much as the percentage of sodium in relation to the exchange capacity. A percentage of over fifteen makes the soil, by definition, an alkali soil and with over 50 per cent the growth of crops is seriously affected. Apart from its toxic effect on plants, sodium has an adverse effect on soil structure, dispersing the

colloids to form a sticky mess when the soil is wet and a hard impenetrable mass when it is dry. This has been clearly illustrated to a local farmer who tried to cultivate the Marios Alkaline type several times before he finally abandoned it. The only hope for this soil is through reclamation by means of leaching with first class drainage, and the application of chemicals.

Another point regarding soils that have a tendency towards alkalinity is often not realized by the Magugu farmers, African and European. This is the fact that if the tendency is there, irrigation with inadequate drainage will emulate the natural process of surfacing of saline seepages, and this will turn a normal alluvium into an alkali soil. This was clearly demonstrated in a field of corn that had one very poor patch devoid of plants despite an otherwise healthy crop over the field as a whole. Investigation showed that an irrigation ditch had been allowed to deteriorate so that the water was spilling out into a slight, non-draining hollow, with disastrous results.

Patchy salinity or alkalinity among the alluvial soils is much more marked to the north of the area, in the Mbuyuni region, where they form only a comparatively thin overlay on the lake-bed and mbuga clays. With such an impermeable subsoil and in view of the topography it is not surprising that surface drainage tends to evaporate. However, the local African, especially in the Mbuyuni

region, shows a preference for these alluvial overlays, however thin they may be, but avoids them wherever they tend to be saline.

An interesting feature of the Magugu Alluvial Complex is the scattered occurrence, in an otherwise normal alluvial type, of a cemented hardpan of notable strength. To a man armed only with a hoe or spade the consistency of this hardpan layer presents an insurmountable obstacle to cultivation if it appears near the surface. It is not confined to the alluvial types but is found also in the lake-bed loose sands. The exact cause of this hardpan is not yet clear, but one possibility is that a particular proportion of certain sized quartz grains in the soil permits an extremely close-packing arrangement. It is interesting to note in this connection that this type of hardpan, when it does occur in alluvial soils, is found in those lying below the promontories of loose sands, and therefore in alluvial soils which have an exceptional high content of quartz sand washed down from the sandy ridges (see Fig. 80). Another possibility, which seems from this survey to be more likely, is that the hardpan layer is caused by unduly high exchangeable magnesium levels in that layer. In either case, this cemented hardpan is to be distinguished from the Marios hardpan which is due to alkalinity.

The cemented hardpan occurs in non-saline soils which have normal levels of exchangeable sodium, and what

is most important, a soil containing the cemented hardpan can be irrigated without deterioration setting in. The hardpan layer always occurs below the topsoil, at varying depths, and forms an impermeable layer to irrigation water. This enables rice to be grown with the minimum expenditure of water, a fact which is well known to the African. In fact, this hardpan type, if the pan layer is not too near the surface, enables one to avoid the dilemma normally associated with rice growing in this region: namely, that irrigation of the sluggishly draining soils tends to bring up their salinity or alkalinity from depth (as with Marios Alkaline soils), whereas the strictly non-saline types (e.g. Marios I) tend to be sufficiently free draining to make water expenditure high. Therefore, it is important to appreciate fully the difference between alkali hardpan (Marios Alkali Pit) which spreads rapidly under irrigation to the topsoil (and therefore affects plant growth due to the toxic effect of sodium and its adverse effect on structure) and cemented hardpan (Kibaoni II) which appears to be stable under irrigation.

The occurrence of hardpan is marked on the map wherever it was found, but the total area of this type can only be ascertained by a much more detailed survey. An example is found in the Kibaoni II Soil Pit (Table X and Fig. 83). Comprehensive analytical data for this soil has not been made as yet, but it is sufficient to say at

present that the soil is non-saline and exchangeable sodium levels are normal.

TABLE X

KIBAONI II SOIL PIT

Depth (in.)	Description
0-6	A grey, friable, crumby, volcanic, fine sandy loam.
6-18	A dark structureless, loose micaceous sand.
18-26	A dark grey, tough, sandy clay; blocky structure with considerable brown staining.
26-30	A black, slightly clayey, coarse sand; cemented and indurated in the field to an almost impenetrable layer; breaks down fairly easily after being dug out.
30-46	A black, silty clay; hard crumby structure; slight brown staining.
46---	A dark, gritty, raw, silty clay; crumby in structure but friable due to porous nature of crumbs.

There remains one group of soils within the alluvial complex that has not been discussed. These are the Skeletal Erosion Detritus Soils. They are not an important group of soils and cover a relatively small proportion of the area along the eastern fringes of the lake-bed soils, below the Sangaiwe Ridge. They consist simply of skeletal material derived from more or less catastrophic erosion of the upper slopes of the ridge which has spread out in fans over the lake-bed soils.

Mbuyuni II illustrates a shallow erosion soil over a typical lake-bed sandy clay (Fig. 85). The first three horizons, covering 0-24 inches, consist of a red brown micaceous, slightly clayey, fine sand below which occurs the highly calcareous, gritty, sandy clay commonly

Fig. 85.--Soil profiles of the Matufa IV and Mbuyuni II Soil Pits.

found in this area. It is a young and fertile soil and will be reasonably stable under cultivation, as it consists of the finer fractions of the eroded material. If irrigated, however, it will be important not to allow the salinity of the underlying sandy clay to rise.

Matufa IV is an illustration of a deep conglomeration of recent erosion debris (Fig. 85). Its main interest lies in the amazing number of layers, all of different textured material, and all coarse and only partially weathered. Its second layer is a highly calcareous gravel, derived no doubt from the colluvial calcareous soils associated with the old red earth catenas on the Sangaiwe Ridge, which lies outside the area under consideration. It has a weathered, brown, clay-loam topsoil and is free draining and can therefore readily be used for the local food crops other than rice. Crop production, however, would be more dependent on rainfall than on the quality of the soil.

One other type of the alluvial complex is quite exceptional and was found in only one spot. This type occupies a small area at the base of Sino Hill and is derived entirely from the basement complex gneisses of the hill. This type is represented by the Sino I Soil Pit (Table XI). The Sino I soil has a dark grey, crumby, silty-clay topsoil, non-gritty (i.e. no volcanic material), over a brown, highly mottled, micaceous, silty-clay with

a small, hard, clod structure, which is massive and non-cracking in the field.

TABLE XI

SINO I SOIL PIT

Depth (in.)	Cond.	pH	Free $CaCO_3$	Org. C.[a]	P.[b] p.p.m.	Ex. Ca.[c] m.e.
0-6	152	8.3	Nil	1.9	5.0	16.2
6-18	151	8.1	Slight	0.78	8.3	17.3
18-30	97	8.2	Nil	1.0	37.2	16.6
30-42	98	8.0	Nil	1.1	33.7	18.3

[a]Percentage of organic carbon.
[b]Phosphorus, parts per million.
[c]Percentage of exchangeable calcium, milliequivalents.

The Sino I soil is non-saline; exchangeable calcium is high; and despite a rather low phosphorus content in the non-micaceous topsoil there seems to be no reason to doubt its inherent fertility. Subsurface mottling, however, indicates that a high water table is normal here with poor drainage. These two factors account for the repeated failure of coffee, paw paws, and cotton on this soil.

Soils summary.--The field and laboratory analyses of all the soil types just discussed allow the observer to summarize that in this area of young soils derived from exposed lake-bed and recent alluvial material, of which a high proportion is of volcanic origin, there is no shortage of plant nutrients. Despite this, to the African, the agricultural potential varies considerably from one soil type to another, because the peasant farmer,

with his limited resources, is forced to take a soil as he finds it. He does not have the facilities to alter drainage to any great extent, and he cannot change the topography or climate, and these factors, as well as the purely chemical fertility of the soils, must play an important part in selecting the land on which he settles. For example, some of the more thickly populated and intensively cultivated soils at Magugu are the Loose Sands, which are found on high-lying, free-draining ridges and which are easily handled, but they are basically the least fertile soils in the region. Nevertheless, a correlation does exist between the soil pattern and the settlement pattern simply because the soil type represents a summation of the influence of so many of the factors which affect an African's choice of land.

Thus on the shallow lake-bed soils, formed under an arid climate, lack of water is the main deterrent to the African, or else, if water is supplied, then it is the difficulties of drainage. With the _mbuga_ clays, on the other hand, two soil characteristics, heavy structure and salinity, have been the overwhelming reason why the African has not made full use of these soils.[1] The distribution of the alluvial complex as a whole is important because these types are sought out by the African, but

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[1]Of course, the fact that, regardless of their soils, the _mbugas_ are subject to periodic flooding has great bearing on the use of these soils.

within the complex the distribution of the differently textured non-saline types has little or no bearing on land usage as they are all fertile. The occurrence of high alkalinity is, of course, of great significance, as the African at present cannot make use of an alkali soil at all. It is with these alkaline soils that modern techniques may have the greatest influence on the settlement plan of the future, as they can be reclaimed, and the African taught to preserve them. Finally, the cemented hardpan soils must be mentioned as an example of the overriding importance of a particular soil characteristic on the choice of a crop.

Speculation might be made on how long it has taken the African in this region to gain his non-technical but accurate knowledge of soil conditions. Although this would open up a whole field of inquiry that could not be determined for this study, a detailed investigation of the present land use pattern at Magugu will reveal how the African has utilized the sum total of his physical setting: location and site, climate, topography, soils, and vegetation to form the present pattern of settlement in the Magugu community.